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Laser Accidents: Being Prepared

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Laser Accidents: Being Prepared

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ABSTRACT:
The goal of the Laser Safety Officer and any laser safety program is to prevent a laser accident from occurring, in particular an injury to a person's eyes. Most laser safety courses talk about laser accidents, causes, and types of injury. The purpose of this presentation is to present a plan for safety offices and users to follow in case of accident or injury from laser radiation.

Key Words: Laser, Accident, Eye injury, Laser Safety Officer, Emergency Response

1. INTRODUCTION

The goal of the Laser Safety Officer and any laser safety program is to prevent a laser accident from occurring, in particular an injury to a person's eyes. With that in mind, most laser safety courses discuss laser accidents, the causes, and the nature of injuries. The purpose of this paper is to help you answer the following questions: Are you prepared for an accident? Is there a plan for the laser safety office to follow? Do laser users know what steps to take if an injury occurs?

2. LASER ACCIDENTS

The application of laser technology is reaching further into society, both the workplace and at home. While most workplaces have an emergency plan in place in case of a fire, few have a plan that deals with lasers. This is true regardless of the hazard classification of the lasers on site or the number of systems. Few workplaces have a plan in place to deal with a worker who believes he or she has been struck by a laser beam. I say "believes" because in my experience, the majority of incidents turn out to be the perception of injury rather than real injury. Often workers see the light from the flashlamps and interpret it as laser light. Whatever action plan is chosen, it should be posted as well as taught to all employees working with or around lasers.

Are laser accidents happening? Although the data is limited, the answer is, yes. One primary source of information is the Food & Drug Administration/Center for Devices of Radiological Health (CDRH). The CRDH maintains a database of laser equipment malfunctions. The database lists the location of the incident, equipment involved, and, when available, a response from the equipment manufacturer. Not every laser accident is user error, but upon investigation, many equipment malfunctions show the user is the root cause of the incident or closely related to it. Below are examples of the types of information found in the CRDH reports, which show an average 20 incidents a month throughout the United States.

Medical Device Report (MDR) Report Key 397304, report number1218402-2002-00019
Event description: The representative of a medical laser manufacturer sent a user an extra pair of laser protective eyewear. The problem was that the extra pair was not for the wavelengths produced by the laser. The eyewear was correctly marked with wavelength OD, but the doctor who received it did not check. He received a reflection that passed through the eyewear and caused an eye injury. This incident was reported to the FDA/CDRH on 5/31/02.

Access number m320116, MDR database
Event description: After connecting the kit and laser, it was observed that the red HeNe aiming beam was not visible at the laser kit tip. The physician elected to proceed with the procedure. When the laser control foot switch was depressed, no laser energy was emitted from the laser tip. Flames appeared on the sterile drape where the laser fiber had been resting. No one was injured. Analysis of the returned product pointed to a broken laser fiber probably caused by mishandling

Access number m751889, MDR database
Event description: A male patient was undergoing micro laryngoscope laser surgery to remove a nodule from the vocal cord. The endotrachel tube was in use when an ignition occurred. The patient sustained severe burns to his vocal cords and surrounding tissues causing obstructive swelling.

Access number m817394, MDR database
A nurse in the operating room leaned into the laser system at the point where the laser delivery fiber attached to the laser console and caused the fiber to break at the connector. The broken fiber caused a burn in the nurse's clothing, penetrated the clothing and caused a small non-serious burn on the nurse's abdomen.

One of the oldest laser accident databases was originated and kept by Rockwell Laser Industries (RLI), a laser safety-consulting firm that collects documented accident accounts. Approximately every 10 years they publish the updated totals of their database. The firm's web page contains a form where accidents and incidents can be reported, which can be found at http://www.rli.com/. A recent publication showed a total of 395 reported incidents between 1964 and 1998. This number appears to be relatively low, however, it is generally believed this is a case of under reporting. The actual number of laser accidents could easily be much higher.

The Department of Energy (DOE) has an extensive accident-reporting database, called the Occurrence Reporting and Processing System (ORPS). Many kinds of accidents and incidents are tracked through this system. Over the last five years, a number of the national laboratories have reported a laser injury or a break in laser safety procedures. A national laboratory Lessons Learned web page can be found at the following address: http://tis.eh.doe.gov/paa/oesummary.html

Examples of DOE incidents:
A Post Doctoral student was attempting to align an unfocused laser beam when a stray beam from an optic polarizer he was holding glanced into his face. No protective eyewear was worn, and eye pain developed in 24 hours.

A researcher performing welding of 24-inch-long aluminum plates using 4 kWatts of power from a carbon dioxide laser caused a ceiling panel to start burning, which was detected when the room smoke detector alarmed. ORPS report CH-AA-ANLE-ANLEER-1999-0005.

The person injured had 15 years experience with lasers. The experiment was running 1 mJ, 500 HZ, and femtosecond pulse length, with a beam size of several centimeters. The beam was aimed in an upward direction toward a periscope. The beam output was not lowered, because it burns through the neutral density filters. The two researchers decided if they were CAREFUL, it would be all right to insert a mirror into the full-power beam path. This activity was a violation of written procedures for the experiment. An IR viewer was not used. One researcher was placing the mirror into the beam path and was struck by reflection from the corner of the mirror. The person heard a popping sound from his eye, followed by swelling of the eye. The result was a 100-micron spot size injury. Vision went from 20/50 to near blindness; the researcher still cannot read large print.

The U.S military keeps databases of incidents and injuries. One is the Laser Accident and Incident Registry, U.S. Army Medical Research Detachment, Walter Reed Army Institute of Research. Two examples follow:
GLIN 4. The subject experienced an immense flash of light and indicated black circles and an almost complete loss of vision. The vision slowly cleared in the next 48 hours, but many dark brown spots continued to form a "curtain" in front of the eye. Assuming the pupil diameter was about 7 mm (dark environment), the retina was exposed to about 4.3 millijoules of total beam energy. The resulting pressure wave caused damage to all the structures in the image area. The bruch's membrane was ruptured posteriorly, the sensory retina and nerve fiber layer were disrupted anteriorly, and at the retinal level, the photoreceptors sustained sever damage peripherally.

Q-SWITCHED ND:YAG INJURY: Israel. Paramacular burn, later puckering and permanent loss of visual acuity. Laser had 1064-nm wavelength with a 20-nsec pulse duration, 20-mJ/cm squared beam energy, and a 4.3-mJ/pulse duration exposure (assuming a 7-mm pupil). The distance to the laser was 0.03 meters.

Finally, word of mouth is a source of laser injury scenarios. At every laser conference, one can hear about laser accidents or incidents that occurred in the last year. Many have the familiar tune of laser alignment without the use of protective eyewear.

From this data, it is clear that laser accidents do occur. The next question is, "How prepared are you and your institution for a laser accident?"

Laser Accident Action Plan

One solution is to place in every laser laboratory a poster that provides the names and current phone numbers of emergency personnel and steps to be followed until help arrives. Keeping the individual calm is the highest priority, with them either sitting or lying down. Avoiding panic or shock is the main goal. If your institution has a central help number for emergencies, call that number. If you have a medical clinic on site, they can be called or notified by your response office. After these calls, notify the individual's or the area supervisor, along with the Laser Safety Officer and others working in the same area or on the same equipment. If an accident occurs in a research institution, it could easily happen after normal working hours. The number to call during off hours should also be listed on the poster. If medical or security is called first, they should have standing instructions to contact the Laser Safety Officer. Many large facilities have a fire department or security force that would transport the individual; they should be instructed on how to handle a person with an eye injury. The sample poster below could also be prepared as a web page. The web page approach has the advantage of quick updates, such as phone numbers and personnel changes.

Below is a sample poster or web page. Additional examples from three universities can be seen at the following web pages

1- http://www-ehs.ucsd.edu/rad/eyeemerg.htm
2- http://radsafe.berkeley.edu/lsr-appg.html
3- http://ehs.unc.edu/radiation/manual/laser/incidents.htm

Sample sign

IN CASE OF LASER ACCIDENT

SUSPECT EYE INJURY
The following action is to be taken:

1.Determne if any local assistance is available, such as a co-worker.
If yes, have them follow steps 2 & 3.
If no, call for assistance, do not go by yourself.
2. Keep the person as calm as possible.
3. Call the Medical/Fire dept., ext. ////////.
Regular hours: you can transport the person to medical.
Off hours: Fire dept. to provide transportation.
4. Notify the Laser Safety Officer at ext. /////. Off hours number: //////////.
5. Notify the individual's or the area supervisor.
6. Work needs to stop until an evaluation is conducted to see if a systematic error exists.

SUSPECTED SKIN INJURY

1. Keep the person calm.
2. Call the Medical/Fire dept.
3. Follow the steps above.
If the injury is a hand burn with no active bleeding, you can transport yourself to medical

Background:
At the scene, reassurance is the most important thing to provide.
Not all laser injuries have an immediate affect on vision, consequently, an initial and follow-up eye examinations are critical.
Let others know what happened.
Work needs to stop until an evaluation is conducted to see if a systematic error exists.

Medical Facility
Depending on your community, you may have limited choices on where to send an individual with a suspected laser eye injury. It is important that the facility have some understanding of laser eye injuries as well as the laser mechanism. Commonly, once the individual informs the medical staff they work with or around lasers, any injury, particularly retinal, will be assumed to be laser induced. Medical personnel may overlook the fact that many other optical causes or disease could be the reason for visual problems or defects. Provide the name of a retinal specialist to the individual for further evaluation or follow up in cases involving visible or near-infrared laser radiation.

Follow Up
Follow up steps are essential for any good accident investigator. Visiting the site is important to get a feel for the work environment and any circumstances that may have contributed to the incident. An investigator should get statements from all those in the area (in writing if possible), take digital pictures capturing the scene, get an explanation of the work being performed, work to determine the root cause, and ask for corrective actions from those involved.

Corrective Actions
In determining the necessary corrective actions, the accident investigator should determine if any established institutional procedures have been violated. The following questions should be considered: Do ANSI control measures provide any solutions or direction for users? Was the proper personnel protective equipment available? What suggestions do the users have to prevent a reoccurrence?

If a report to management is required or suggested, allow the users to review it prior to submitting the report to others to see if changes need to be made. The use of digital photos in the report is an excellent way to explain points to non-laser personnel.

Lessons Learned Notice
Once the facts of the incident are understood, a Lessons Learned notice should be written and distributed to the institution's laser user community. This notice should not be a document to blame someone for the incident, but rather to point out the contributing factors and how the incident can be prevented from happening in the future.

Summary
Every Laser Safety Officer is tasked with taking steps and developing controls to prevent laser injury. The reality is that if an accident occurs, the Laser Safety Officer has to be prepared to deal with the incident and aftermath. Failure to do so may cause a loss of faith in the safety program, in addition to putting the injured party through greater stress. Your answer to the question, Are you prepared for a laser accident?, should be "yes." If not, a roadmap has been laid out, so you will be able to say "yes."

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Meet the author:
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